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GEOGRAPHIC INTELLIGENCE REPORT

AGROCLIMATIC FACTORS AFFECTING RICE CULTURE IN COMMUNIST CHINA

(Preliminary Draft)

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Appendix

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I. Objectives and Methodology

The purpose of this study is (1) to analyze agroclimatic factors that influence the potential distribution of rice cultivation in Communist China and (2) to provide the climatic bases for determining the possibility of extending the areas in which rice can be grown. This report constitutes a pilot study to test both the adequacy of available climatic and agronomic data and the agroclimatic methodology used. In general, the data on the critical climatic requirements for the germination, growth, and ripening of rice are derived from the published results of crop research in parts of China and in analogous areas. These data are then correlated with climatic data available for the China mainland.

II. General Background

1. Ecological Development

The agroclimatic evaluation of current rice production in Communist China and of possible future production is complicated by (1) the ecological adaptability of the rice plant (Oryza sativa) to nearly all environmental conditions encountered between 40°N and 40°S latitude; (2) the resultant development of thousands of native varieties of rice, generally related to two main types (O. sativa indica and O. sativa japonica); and particularly by (3) a lack of information on the distribution and characteristics of local varieties of rice throughout China. Commercially grown rice in the Far East consists primarily of various strains of O. sativa japonica, which is cultivated chiefly in Japan, Korea, Taiwan, and Northern China; and of O. sativa indica, to which most native types

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in South China belong. Both types are found in Central China. Japonica rices are generally characterized by high yields, good response to intensive manuring, a short nonlodging* straw, a coarse round grain, and a higher ratio of husked rice to unhulled grain than is found in Indica strains. Indica rices have a longer grain, generally have lower yields, and are more susceptible to lodging because of the heavy vegetative growth they develop when manured. They are hardier, however, and more resistant to unfavorable environmental conditions.

Figure 1 shows the growth of one variety of rice (Norin No. 8), which was planted at the Konosu Agricultural Experiment Station in Japan. Varieties of rice from all areas of the world have been studied by Japanese agronomists and classified into three broadly inclusive types, or ecotypes**, whose geographical distribution was found to be closely related to their hypothetical centers of origin. The major ecotypes -- "A", "B", and "C" -- are most widespread in Japan, Java, and India, respectively. For the purpose of establishing general agroclimatic requirements of rices grown in China according to their regional

* Under various adverse conditions of drainage or too rapid growth prior to heading, the rice plant develops a weak stem and the panicles bend over. Such plants are particularly vulnerable to storm damage because the stems and heads pack, or lodge, together; this phenomenon is known as "lodging". Some varieties of O. sativa are more susceptible to lodging than others.

** An "ecotype" represents a group of botanical types belonging to one species that are unified by certain common genetical characteristics, particularly those adapted to the ecological environments of a given area. The well known Japanese, Javanese, and Indian ecotypes are generally referred to as types.

distribution, the three ecotypes of O. sativa that were developed through agronomical research in Japan are assumed to be representative of native Chinese types. In China, however, the rice plants related to A, B, and C ecotypes have been modified through their adaptability to different regional environments. Table 1 shows the distribution by percentage of the three major rice ecotypes in various parts of China. Their distribution, however, is no indication of the acreage sown to each or of the volume of rice production from each type grown.

Table 1

Distribution of Selected Ecotypes of Oryza sativa in China a/

Percent (in rounded figures)

Area	Type A (Japanese, Japonica)	Type B (Javanese)	Type C (Indian, Indica)
Manchuria	66	22	11
North China	29	21	50
Middle China	39	1	60
South China	9	3	87
West China	0	0	100
Taiwan	27	0	72

a. All data were taken from source 5/.

Inferences about rice production that may be drawn from the distribution of the three main types throughout China must of necessity be confined to generalizations on the kind of problems that are likely to occur in the areas listed, since information on the extent of planting is lacking.

2. Interrelation of Basic Vegetative Growth, Photoperiod, and Temperature

Rice is normally considered to be a short-day plant because heading and ripening are usually accelerated as the days become shorter. Since late varieties are usually sensitive to day length, they must be grown only during a specific season of the year. Early varieties, however, are normally not sensitive to the length of days and can be grown during any part of the summer and autumn. 1/

In Japan, studies of Japanese varieties of rice grown under experimental conditions simulating periods of short days and periods of high temperatures indicate a close interrelation of basic vegetative growth, photoperiod response, and temperature response.* Rice varieties with low photoperiod responses are usually grown in northern latitudes and exhibit an increasing sensitivity to temperature as the latitude becomes higher. With northern varieties, heading occurs upon completion of the basic vegetative growth of the plant, irrespective of the length of days. The time required for heading may be shortened, however, by high temperatures in the summer. 2/

Japanese varieties with a high photoperiod response are usually planted in double-cropping areas where the shortening of the days after the 1st of August induces early heading in the second crop. In such areas in Japan, early-maturing varieties with low photoperiod responses are usually planted as the first crop and medium-maturing varieties

* For purposes of this report, the basic vegetative growth of a rice plant is considered to be that which is made during a period that is affected neither by short days nor high temperatures. In recording the results of the Japanese controlled treatment of selected rice varieties, the factor used for "basic vegetative growth" is the number of days in such a growing period. The factor of "photoperiod response" is the number of days that the period from seeding to heading can be shortened by planting rice during a short-day (10 hours) season under normal temperature conditions. Conversely, the "temperature response" factor is the number of days that this period from seeding to heading can be shortened by planting during a season of high temperatures if the days are of medium length.

with high photoperiod response as the second crop. 3/ Day lengths at latitudes between 20° and 50°N are shown in the following tabulation:

	Hours and Minutes		
	Spring (March 21)	Summer (June 22)	Fall (September 23)
20°N	12 h 0 m	13 h 12 m	12 h 0 m
30°N	12 h 0 m	13 h 56 m	12 h 0 m
40°N	12 h 0 m	14 h 52 m	12 h 0 m
50°N	12 h 0 m	16 h 18 m	12 h 0 m

Studies of rice varieties in Fukien, for example, using day lengths of 5, 7, 9, and 11 hours, showed that vegetative growth and the development of tillers* were greatest in an 11-hour day, and were noticeably less during a shorter photoperiod. The studies included 1 early, 1 medium, and 1 late variety. The time of heading was not influenced by day length in the early variety, but heading in the medium variety occurred 11 to 16 days earlier in short-day treatments. In the late variety, the time of heading occurred 63 to 74 days earlier, or half the total vegetative period, in the short-day experiments. 4/ Thus, the relationships between vegetative growth and length of days observed in Japanese studies of Chinese varieties appear to hold true in at least one area of China. No information is available on such relationships for other rice-growing areas on the mainland.

* A tiller is a sprout, shoot, or stalk of any grain, especially one that comes from the root of the plant or from the axils of its lower leaves. "Tiller" and "tillering" are also used in verb form to indicate the putting forth of new stalks, or tillers.

Despite the lack of information on the growth characteristics of specific Chinese varieties, it can be assumed that relationships between photoperiod, temperature response, and vegetative growth developed by Japanese research on Chinese varieties will provide a base for measuring the effects of the same factors for rice grown on the mainland. Distributions of such relationships for varieties of rice grown in Manchuria, North China, Central China, South China, and West China are shown in Figures 2, 3, and 4. 5/

3. Characteristics of Rice Grown in China

Most varieties grown in northern latitudes such as Manchuria and North China (chiefly Japonica types) have moderate-to-high sensitivity to temperature and low sensitivity to day length as well as a moderately low basic vegetative growth (see Figure 2). Climatic characteristics of the higher latitudes include relatively low temperatures during the initial period of growth and days that become progressively longer as the time for heading approaches. The phenological chart (Figure 11) for Shensi (Nancheng), which is selected as representative of high latitude locations, shows that the northern varieties are able to accomplish the minimum vegetative growth required to support their flowering and heading within a shorter-than-average growing period. Since northern rice is not highly sensitive to day length, flowering and heading can occur without the periods of short days that are generally necessary to induce generative rather than vegetative growth. Furthermore the low temperatures in the latter part of the growing period reduce the danger of heading before the basic vegetative growth of the plant has been completed.

Mid-latitudinal varieties of rice such as those grown in Central, South, and West China have varying responses to temperature and day length, depending upon whether they are early- or late-maturing varieties (Figures 6 and 7). Early varieties are often the first crop in a double-cropping combination, or they may be the only crop in other types of rotation. In South China, early varieties exhibit a low sensitivity to day length and a high sensitivity to temperature (Figures 3 and 4). In the latitudes of Central China, temperatures during the initial period of growth are low and days are short (12 hours). As the growing period progresses and the date of flowering and heading approaches, the days become longer (14 to 15 hours) and temperatures increase. Since the early varieties are not sensitive to day length, they can grow to the flowering and heading stage in spite of the fact that they experience no period of short days. Late varieties grown in mid-latitudes, however, have the opposite characteristics: high sensitivity to day length and relatively low sensitivity to temperature. Temperatures during the initial growth period of late varieties in Central China, for example, are high and the days are long. In subsequent periods of growth leading to flowering and heading, mid-latitude temperatures fall and days become shorter. Being highly insensitive to temperature, the late varieties are not affected by the high temperatures at sowing time. These varieties, however, are sensitive to length of day, and consequently the shorter autumnal days accelerate the progress toward flowering and heading. The plants are thus able to complete their growth cycle before fall frosts occur. Late varieties are therefore used as a fall crop or as the second crop in double cropping.

III. Temperature Requirements

1. Germination

Rice appears to require higher temperatures for germination than other major grains. Within limits, the speed of seed germination increases with the increase of temperature, but optimum temperatures for the germination of rice are between 86°F and 95°F (30°C and 35°C). 6/ Most northern varieties of rice, however, can germinate at temperatures as low as 50°F to 55°F (10°C to 13°C), whereas varieties grown near the Equator may require from 59°F to 68°F (15°C to 20°C). 7/ The maximum temperature for rice germination in Japan is 104°F (40°C), the optimum being the normal 86°F to 95°F and the minimum between 50°F and 54°F. Optimum temperatures for early varieties generally tend to be lower than those of the later varieties. 8/

Indica rice -- the type most widely grown in China as a whole -- generally has the best germination rate at low temperatures. Although a few varieties require 60°F to 63°F (16°C to 17°C) for germination, most varieties have a minimal germination temperature requirement of 59°F (15°C); a few can germinate at 55°F or 57°F (13°C or 14°C); but none will germinate in temperatures below 55°F (13°C). Most of the rices planted in North China, however, are of the Japonica type. They require at least 55°F (13°C) for germination, but a few will germinate in temperatures as low as 52°F to 54°F (11°C to 12°C). Only one variety requires a temperature of 57°F (14°C) for germination. 9/ Maps 1 and 2 show the average dates of the first and last occurrence of 50°F daily mean temperature in China.

2. Vegetative Growth

The maximum temperature for seedling growth in Japan is 86°F (30°C) and the minimum temperature is 45°F to 46°F (7°C to 8°C). The generally accepted optimum temperature for the healthiest growth of seedlings in Japan is 73°F (23°C). 10/

During its growing season, rice usually requires temperatures of about 68°F (20°C) for at least 2 or preferably 3 months. 11/ The generally accepted optimum temperatures for the stages of tillering and formation of young ears (see Figure 1) are 90°F to 93°F (32°C to 34°C) and 86°F to 90°F (30°C to 32°C), respectively. The actual optimum temperature varies, however, with the variety and with the stage of plant growth. Temperatures below the optimum during the early period of seedling growth retard their growth and delay the transplanting date. Low temperatures during the tillering stage of vegetative growth inhibit the development of tillers.

The flowering and heading of rice may be delayed by temperatures below the optimum. Optimum temperatures for flowering are between 80°F and 90°F. 12/ High nighttime temperatures, however, are undesirable during flowering, whereas experiments show that a marked difference between day and night temperatures has a beneficial effect on the maturing rice heads. 13/ Low daytime temperatures tend to retard the initiation of the flowering stage and high temperatures (near the optimum) accelerate it. The average number of days in a year having daily mean temperatures higher than 50°F (for China) are shown on Map 3.

3. Heat Summation

Temperature requirements for the growth of rice plants can be expressed in terms of heat summations as well as in terms of the permissible temperature ranges for germination, vegetative growth, flowering, heading and maturation discussed above. By using as a base the minimum temperatures at which growth occurs, the additional heat required to mature a crop may be used as an index to the feasibility of rice cultivation in a particular area. Such heat summations are computed by totaling the number of degree-days* that can be accumulated in a specific area between germination and harvest. For the same variety of rice, temperature summations may vary considerably under different growing conditions. Temperature summations in the higher latitudes tend to be lower than in the tropics, possibly because the growth of temperate varieties may be reduced rather than increased by excessively high temperatures. The longer duration of sunlight in higher latitudes during the summer may also compensate in part for the lower summations of heat. 14/

A comparison of heat summations for Japanese varieties grown as far north as Hokkaido (44°N) and as far south as Shikoku (about 34°N) suggest that there is little difference in the summation of heat required to grow specific varieties in different latitudes. 15/ The earliest

* A degree-day, the heat unit generally used in computing heat summations, is expressed as one degree of temperature above the base for one day, the total degree-days for one day being the difference between the mean temperature for that day and the base. Japanese heat summations are computed on a base of 32°F (0°C), and represent the accumulated degrees of temperature higher than 32°F for all the days of a growing season. For approximations of probable heat summations in China, 50°F (10°C) seems a more realistic base.

varieties require only about 4352°F (2400°C) heat summation to complete their growth cycle from seeding to harvest. Most early varieties, however, require from 4712°F to 5432°F (2600°C to 3000°C) heat summation during their growing seasons, and late varieties require only slightly more (5581°F or 3083°C). Conclusions drawn from Japanese experience indicate that the rice varieties tested require the ranges of heat summations indicated above regardless of the latitude or the length of growing season. Thus two successive crops a year can be raised where the annual heat summation exceeds 7952°F (4400°C) if a very early variety is selected for the first crop and if the last 752°F (400°C) of this amount of heat can also be devoted to raising the seedlings for the second crop in nursery beds. For normally early varieties requiring as much as 5432°F (3000°C), double cropping will require a total of 8672°F (4800°C). 16/

Information on optimum or minimum heat summations required to mature Chinese rice crops is not available. Tentative approximations of optimum heat summations for early and late Chinese varieties can be derived from the Japanese summations indicated above together with an analysis of heat summations in the phenological charts (see Figures 5-11). 17/ Thus it is assumed that early varieties of rice, regardless of the latitude in which they are grown, will require from 2600°F to 3200°F of heat above 50°F. Late varieties will require from 3200°F to 3400°F, and double cropping will require a total of 5800°F to 5600°F of heat above 50°F. 18/ Figure 5 gives heat summations over 50°F for all of China (from 85°E to 130°E) by intervals of 5 degrees of latitude between 25°N and 50°N and also for "agricultural China" (from 110°E to 130°E).

IV. Water Requirements

1. Supply

The consensus of experts on the problems of rice cultivation in the Far East and Southeast Asia appears to be that the chief limiting factor to the growth of rice is water supply. Grist contends that, compared with water supply, the suitability of the soil for rice growing is relatively unimportant. 19/ In Asia alone there are many varieties of paddy rice. Some are drought-resistant and others flood-resistant; some can be grown in brackish water and others require fresh water; collectively they exhibit a wide variety of tolerances to sunshine, temperature, and other climatic factors. It is generally agreed, however, that some variety of paddy can be grown under almost any climatic condition within 40 degrees north or south of the equator and on nearly every kind of soil, if given an adequate supply of water. 20/

The definition of "an adequate supply of water", however, has no such consensus. The optimum amount of water required for adequate tillering of a growing rice crop varies among the various producing areas in the world and even among rice-growing areas of the Far East that have nearly analogous climatic and cultural conditions. Contrary to general opinion, the most favorable climatic regions for the growth of rice are those characterized by a seasonal cycle of precipitation rather than the tropical rainforest regions -- which have heavy rainfall and little or no dry season. If no provision is made for timely irrigation, regions that have a yearly average of at least 40 inches of rainfall (mainly concentrated in the growing season) appear to be optimum. Also important is a relatively dry season during the time when the rice matures. 21/ Since most rice in Communist China is irrigated paddy, the availability of water for irrigation is of greater relevance to the problems of rice culture than are climatic conditions. The regional patterns of moisture deficiency and surplus in mainland China, however, considered in relation to water requirements of rice, may afford a measure of regional water needs for rice culture. The average annual water deficiency and surplus for China is shown on Maps 5 and 6. A tentative assessment of the probability of success or failure of the rice crop in any particular year should be possible if the water requirements are considered in connection with the availability of irrigation water.

The principal factors determining the effect of water on the growth of rice are quantity, quality, and control. The total annual water requirement varies with the varieties grown and with the region of cultivation, but the principal factors that influence the consumption of water are field evaporation, seepage, differences in soil preparation, and the amount and method of initial flooding. The minimum water requirement for paddy is estimated at about 3.2 acre-feet 22/ but, except in Japan -- where the total requirement amounts to only 2.3 to 4.3 acre-feet -- the most common total water requirement for irrigated paddy is 6 acre-feet. 23/ The degree of variation in total water requirements that may be expected even within the same general growing area, however, is exemplified by the contrast between northern and southern Taiwan, where the amounts of water required for the 135-day irrigation season are reported as 3.75 and 5.63 acre-feet, respectively. 24/ For purposes of a climatic evaluation of rice irrigation in mainland China a total annual water requirement of 5 to 6 acre-feet is assumed.

2. Control

One of the most critical factors affecting the germination, growth, and maturation of rice is the control of the water supply during the growing season, which includes the timely application of water at depths that will insure the optimum growth of the crop and also the provision for adequate drainage of the fields at certain periods of plant growth. It is generally agreed that paddy should be grown in a well-soaked field, but with little standing water since it suppresses the production of tillers in the vegetative growth stage. 25/

A large supply of water is required for the preparation of a field by wet tillage before planting. In areas of heavy paddy soils, this preliminary requirement may amount to 30 percent or more of the total water requirement for the crop. 26/ The chief purpose of irrigation before planting is to facilitate the intensive soil tillage necessary to create the so-called puddled soil condition in which a 6- to 8-inch layer of soil is worked into a consistency of fine soft mud. Although practices vary from place to place, the depth of water is generally increased gradually as the newly transplanted rice plants grow until a depth of 6 to 12 inches is reached. 27/ A rice plant uses a comparatively small amount of water immediately after it has been transplanted, and the depth of water at this time is usually kept at about the 2 inches necessary to check weed growth. As the plant grows, however, the quantity of moisture transpired increases and the depth of the water on the field must be gradually increased first to 4 inches and later to 8 to 12 inches. 28,29/ Although water promotes and maintains the soil texture and temperature necessary for the growth of young seedlings, the drainage of soils is necessary for aeration in later stages of growth. 30/

As a result of experiments conducted in India, the total amount of water required for each acre during the different stages of plant growth was determined to be as follows: (1) seedbed, 1 acre-inch; (2) after transplanting and during vegetative growth, 22 acre-inches; and (3) maturation period, 37 acre-inches. The application of water to a depth of 2 inches at intervals of 3 to 4 days was found to give best yields, and on the average the rice crop in India requires the application about a half inch of water per day. 31/ Other Indian experiments indicate that the chief periods of high water requirement during the growth cycle of the rice plant come during the initial seedling period (about 10 days), the preflowering and flowering period (about 25 days), and the grain formation period of about 5 to 7 days. Yields are adversely affected if there is a deficiency of water during these periods. Probable periods of water deficiency in China can be derived from the climatic graphs shown in Figures 6 through 9.

3. Quality

In addition to the quantity and control of the water supply required for a growing rice crop, certain characteristics of the water itself may adversely affect rice yields. During the seedling and tillering phases of vegetative growth, temperatures of irrigation water can delay plant growth, causing rudimentary plant growth, retarded flowering and heading, or even sterility. 32/ Japanese studies indicate that 90°F (32°C) is the optimum water temperature and that the use of water at other temperatures results in retarded growth and decreased yields. 33/ The lethal maximum temperature is 122°F (50°C). For normal growth of the rice plant, the minimum water temperature is 55°F (13°C) and the maximum something between 102°F and 108°F (39°C and 43.5°C). 34,35/ Studies on the effect of water temperature have usually included the effects of water stagnation and turbidity. In general, it was found that rice plants covered with turbid water for 10 days or more during flood were killed, whereas plants in fields flooded with clear water usually recovered after the water had receded. 36/ Stagnant water had a similar effect on plants in flooded fields. In irrigated fields of semiarid or temperate areas, however, salt damage is the most serious problem. Considerable difficulty is experienced in preventing salt damage resulting from the rapid evaporation of water on the fields during periods of drying winds. Water shortages also complicate the problem of providing fresh water to flush out increasing salt deposits since "new" irrigation water during droughts may prove to have nearly the same or often a higher salt content than the "used" drainage water from the fields. Climatic conditions that exacerbate drought conditions include strong, dry spring winds together with high temperatures.

V. Phenological Aspects of Rice Culture in China

1. Phenological Charts

The approximate dates of sowing, transplanting, and harvesting rice as well as the date of heading and the periods of seedling growth, vegetative growth, and ripening are shown in Figures 6 through 11 for single, double, or interplanted crops in representative areas of North, Central, and South China. The charts also include the mean monthly temperatures during the growing period, a summation of degree-days of heat during the growing period of each crop, and a graph showing the relation between the precipitation-potential and evapo-transpiration at a representative station in the area. A synthesis of the critical climatic requirements for rice growing in each area is indicated by the phenological chart for the area. When correlated with maps showing the distribution of the critical climatic elements in China, the charts provide the basis for a tentative evaluation of the composite optimum for rice growing in each area and a rough approximation of the geographical limits for rice cultivation.

2. Kwangtung and South China (Hong Kong)

The phenological aspects of rice cultivation in Kwangtung and South China are represented by the phenological chart for Hong Kong (Figure 6). Almost 90 percent of the varieties raised are Indica rices with basic vegetative growth, photoperiodic, and temperature characteristics similar to those indicated in Figure 6. The early crop is relatively insensitive to day length and can progress to flowering and heading, and can mature without requiring periods of short days. The late crop is relatively insensitive to temperature and can be planted during periods of high summer temperatures. Its flowering and heading, however, is accelerated by the shorter days in the fall. The growing period is long enough for the crop to mature before danger of frost damage. The most critical climatic problem is a possible shortage of precipitation during the seedling and early growing period of a nonirrigated early crop in dry years, and the lack of periods dry enough to mature and ripen the early crop in June and July. Rainy and dry spells coincide advantageously with the growth characteristics of the late crop.

3. Upper Yangtze Valley (Szechwan)

In the Upper Yangtze Valley, photoperiodic, temperature, and growing period conditions are about the same as those for Hong Kong. In some areas, however, a water deficiency is indicated for the midsummer, coinciding with the late crop seedling and transplanting period (see Figure 7). Map 3 shows that the area has a range of only 0 to 12 inches in the average annual water surplus, suggesting that irrigation requirements may be critical in dry years.

4. Middle Yangtze Valley (Hankow)

Critical climatic conditions for double cropping in the Middle Yangtze Valley (Figure 8) include the possibility of frost during the seedling period of the early crop, excessive rainfall during the harvest of the early crop, and a possibility of water deficiency during the late summer and early fall. Shortage of water during the critical preflowering, flowering, and grain formation periods of the late crop would adversely affect yields.

5. Lower Yangtze Valley (Shanghai)

Phenological conditions for both interplanting and double cropping systems of cultivation are given for the Lower Yangtze Valley (Shanghai) and the southern Huai River plain in Figures 9 and 10. Figure 9 shows the differences between a short-season, early-maturing crop and a long-season, late-maturing crop that is interplanted simultaneously with or shortly after the planting of the early crop. In this area the high temperatures and long days of midsummer indicate the desirability of selecting early varieties that do not require short days to accelerate heading and ripening but which instead are induced to mature by high temperatures. On the other hand, varieties chosen for the late crop, although planted at about the same time as the early crop, are relatively insensitive to temperature but have a fairly high sensitivity to the shorter days of September and October. High summer temperatures may serve to accelerate vegetative growth of the late crop, but may also affect it adversely if the high temperatures occur during the period of rainfall deficiency in July and August.

A possible double-cropping schedule in the Lower Yangtze intertilled crop area is indicated in Figure 10. In order to accommodate two successive crops during the growing season, early and late short-season rice varieties are necessary, with the seedling period of the second crop overlapping the late maturation period of the first crop. Growth, temperature, and photoperiod characteristics of the varieties used for the two crops should be similar to those of varieties planted in other double-cropping areas. Moisture distribution, however, favors the water requirements of the first crop; the seedling period of the late crop coincides with a period of water deficiency in July and August.

6. Han River Valley (Nancheng)

A single cropping system in the Han River Valley of Shensi is shown in Figure 11, together with a tentative double-cropping system proposed by the Chinese Communists. The single-crop schedule is probably representative of growth, temperature, and photoperiod responses similar to those discussed on page 6. Flowering and heading occur during the long days of August and, therefore, varieties that do not require short days to mature are used. In order to advance the growing period, seedlings for the early crop in a double-cropping system would probably have to be raised in hotbeds to escape damage by early frost. The harvest date of the late crop would approach dangerously the average date of the first frost.

VI. Application of Agroclimatic Analysis to Crop Estimating

The tentative nature of some of the climatic requirements developed in this study is necessitated by lack of information on their applicability to Chinese varieties of rice. Unless further details on the growth factors of Chinese rices are developed through more intensive study of available sources or unless additional information can be obtained from Chinese Communist sources, the value of further refinement of critical climatic factors through analogous-area study is doubtful. The validity and value of the agroclimatic factors developed in this study, moreover, can be determined only by a trial application of the factors to an actual growing-season situation in China. It should be possible for analysts in the United States to maintain a trial accounting of accumulated degree days for representative rice growing areas in China, and to relate these heat summations to critical germination, growth, flowering, and ripening temperatures. It would then be possible to correlate such data with the balance between evapotranspiration and the precipitation potential for the area. Using the average conditions and optimum requirements that are indicated in this report together with the monthly mean temperature and precipitation readings already being supplied by Air Weather Service, it should be possible to keep a running account of agroclimatic conditions for a current year's rice crop. Such bookkeeping procedure should provide at least an approximation of the chances for success or failure of the rice crop in various parts of China, especially when related to the availability of irrigation water. By checking the results of the accounting procedure against Chinese Communist reports of crop successes or failures, in time it may be possible to build up an evaluation of the validity and reliability of the procedure and of the agroclimatic parameters. Should studies of yields, areas sown, and the extent of double cropping be possible at a later time, the results of the accounting procedure for agroclimatic data could be incorporated in them.

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